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March 27, 2023

File: S13L1-007

Benjamin Fraser
Environment and Regulatory Advisor
Imperial
505 Quarry Park Blvd S.E. Calgary AB T2C 5N1

Sent by email.

Dear Benjamin Fraser,

Re: 2021 Aquatic Effects Monitoring Program Annual Report - Approved – Imperial Oil Resources N.W.T. Ltd. - Norman Wells Operations

The Sahtu Land and Water Board (Board) met on March 21, 2023, and considered the 2021 Aquatic Effects Monitoring Program Annual Report¹ submitted by Imperial on April 29, 2022 as required by Water Licence (Licence) S13L1-007.

The Board has determined that the 2021 Aquatic Effects Monitoring Program Annual Report meets the requirements of Part I, Condition 3 of the Licence. The Board hereby approves the 2021 Aquatic Effects Monitoring Program Annual Report as submitted. The details of the Board's decision are set out in the attached Reasons for Decision.

The Board notes that the agreed upon recommendations for changes to the AEMP Design, as detailed in the Reasons for Decision, will be reviewed for conformity during the regulatory review process for AEMP version 4.0.

Please direct questions or concerns regarding this letter to Paul Dixon, Executive Director, in writing.

¹ See SLWB Online Registry www.slwb.com for S13L1-007 – [2021 AEMP Annual Report](#) – April 29, 2022

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Tanya MacIntosh', with a long horizontal stroke extending to the right.

Tanya MacIntosh
Chair, Sahtu Land and Water Board

BCC'd to: Imperial Oil ORS Distribution List
Jody Crawford, Conventional Operations Superintendent, Imperial
Tim Morton – Inspector, CIRNAC

Attached: Reasons for Decision



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Reasons for Decision

Issued pursuant to subsection 72.03(1) and section 72.25 of the *Mackenzie Valley Resource Management Act* (MVRMA)

Water Licence Submissions for Board Approval	
File Number	S13L1-007
Company	Imperial Oil Resources N.W.T. Ltd.
Project	Norman Wells Operations Aquatic Effects Monitoring Program (AEMP) and Special Effects Study (SES)
Location	Proven Area, Norman Wells, NT
Activity	Industrial Oil and Gas Production
Date of Decision	March 21, 2023

On March 21, 2023, the Sahtú Land and Water Board (SLWB or Board) met and considered two Submissions made on April 29, 2022, for approval:

1. 2021 Annual Norman Wells Aquatic Effects Monitoring Program Report¹, and
2. Special Effects Study².

After reviewing the submission and the evidence gathered during the regulatory proceeding, the Board has made the following decisions:

- 1) To APPROVE 2021 Aquatic effects Monitoring Program Annual Report, noting that
- 2) The implementation of agreed upon recommendations from the review of the 2021 AEMP Annual Report into the AEMP Design, will be reviewed for CONFORMITY during the regulatory review process for AEMP version 4.0.

¹ See SLWB registry for S13L1-007 - [2021 Annual Norman Wells Aquatic Effects Monitoring Program Report](#) – April 29, 2022

² See SLWB registry for S13L1-007 - [Special Effects Study](#) – April 29, 2022

3) To NOT APPROVE the Special Effects Study as a final report, and DIRECT Imperial to:

- i) provide written clarification of the process(es) for discharging all releases of water from Category A island bunkers within 30 days of this letter,
- ii) implement the recommendations of reviewers to demonstrate that the visible sheen method is appropriately sensitive to validate the assumption that a sample with no visible sheen has non-detect hydrocarbons above Guidelines, and
- iii) resubmit the results of the visible sheen test following May 2023 and any other months of additional testing necessary to sample several types of category A and B SWROFs for results, within 90 days of completion.
- iv) carry forward all other recommendations from reviewers identified as actionable items by Imperial, to the proposed update and revision of the Groundwater Monitoring Plan (GMP) and GMP SNP Program, including the trigger analysis, the hydraulic interconnectivity assessment, and the assessment of Key Indicator Parameters, and resubmit to the Board for approval in one year.

These Reasons for Decision set out the Board's regulatory process for the Submissions and rationale for decisions regarding them.

1.0 List of Defined Terms and Acronyms

AEMP	Aquatic Effects Monitoring Program
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CCME	Canadian Council for the Ministers of the Environment
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
COPC	Contaminants of Potential Concern
DFO	Department of Fisheries and Oceans
DIAND	Department of Indigenous Affairs and Northern Development
Distribution List	The list of individuals and organizations to whom materials from the regulatory proceeding were circulated. ³
ECCC	Environment and Climate Change Canada
EQC	Effluent Quality Criteria
FWAL	Fresh Water Aquatic Life
GNWT	Government of the Northwest Territories
GNWT-ENR	Government of the Northwest Territories – Environment and Natural Resources
GNWT-EAM	Government of the Northwest Territories – Environmental Assessment and Monitoring
GMP	Groundwater Monitoring Program
HESL	Hutchinson Environmental Science Ltd.
Hg	Mercury
INAC	Indigenous and Northern Affairs Canada
Inspector	An Inspector designated under subsection 84(1) of the Mackenzie Valley Resource Management Act

³ To access the Distribution List, see the LWBs' Online Review System for Imperial Oil Norman Wells Operation – [2021 Aquatic Effects Monitoring Program Annual Report and Special Effects Study](#) – June 10, 2022.

IORL	Imperial Oil Resources Ltd.
KIP	Key Indicator Parameter
Licence	Water Licence S13L1-007
Licensee	Imperial Oil Resources N.W.T. Ltd.
LWBs	Land and Water Boards of the Mackenzie Valley
MVRMA	Mackenzie Valley Resource Management Act
ORS	Online Review System (https://new.onlinereviewsystem.ca/reviews)
PAH	Polycyclic Aromatic Hydrocarbons
PCA	Principle Component Analysis
PHC	Petroleum Hydrocarbons
PSD	Passive Sampling Devices
RPD	Relative Percent Difference
SES	Special Effects Study
SLWB or Board	Sahtú Land and Water Board
SNP	Surveillance Network Program
SRRB	Sahtú Renewable Resources Board
SWROF	Surface Water RunOff Facilities
TPH	Total Petroleum Hydrocarbons
VOC	volatile organic compounds like BTEX
WQG	Water Quality Guidelines

2.0 Summary of Regulatory Review Process for the Submissions

- **September 23, 2021**, the Board directed Imperial to submit the Special Effects Study per Part I Condition 1 and Schedule 6, Conditions 1 and 2 that was due on **June 3, 2015**.
- **December 16, 2021**, Imperial presented a timeline, acceptable to the Board, to submit with the Special Effects Study with the Annual AEMP Report, due April 31, 2022.
- **April 29, 2022**, Imperial reports submitted to SLWB.
- **June 10, 2022**, Items were uploaded to the Board's Online Review System (ORS) and distributed for Public Review using the Imperial Oil Distribution List (48 organizations total with 23 in the Sahtú) with an initial deadline of July 8, 2022, for submission of Reviewer comments and recommendations and July 22, 2022, for Proponent Responses.
- **July 6, 2022**, SLWB received and granted request for extension until July 29, 2022, to submit comments from GNWT-ENR and revised the deadline for Responses until August 23.
- **July 29, 2022**, Deadline for submission of comments and received from ECCC (July 11) SRRB (July 18) GNWT-ENR-EAM, DFO, SLWB (July 29).
- **August 23, 2022**, SLWB received and granted a request for a two-month extension for the submission of the responses to comments on this review item.
- **October 28, 2022**, Deadline for Proponent responses and received.
- **March 21, 2023**, Board Meeting to receive for approval.

In making its decision and preparing these Reasons for Decision, the Board has reviewed and considered:

- 1) The Submissions and responses made by the Licensee,

- 2) The comments and recommendations, evidence, and submissions received by the Board from Parties during the regulatory proceeding.

3.0 Main Issues Raised During the Regulatory Proceeding

3.1 Part I: ANNUAL AEMP REPORT

The requirements for the Annual AEMP Report are outlined in Part I: Condition 3 AEMP ANNUAL REPORT. The purpose of the Annual AEMP Report is to provide the Board and all interested parties the opportunity to receive and review data and analysis from monitoring activities and to provide a platform for interested parties to submit comments, observations, feedback, questions, and recommendations as necessary. The program design is revisited every few years or as necessary to adapt the program design in response to program results and assessments. This report is for Board approval.

These Reasons for Decision are based on the following issues raised and considered during the regulatory proceeding:

- A. The 2021 AR was the second annual report submission made by Imperial. Reviewers noted some differences in the way statistical tests were applied and data analyzed between the 2020 and 2021 Annual AEMP Reports; therefore, the results could not be directly compared from the two years. However, many recommendations were made by reviewers to improve the data collection, analysis, and statistical testing and these were agreed by IORL to carry forward into AEMP 4.0 - ISSUES AGREED TO BE ADDRESSED IN AEMP Version 4.0 - see APPENDIX 1a Items a) to m).
- B. IORL submitted additional information in response to requests for raw data, or more fulsome descriptions of methods, or clarification of information presented. This information can be found in the Review Comment Table Summary Attachment 1 – ISSUES AGREED TO AND ADDITIONAL INFORMATION SUBMITTED - see APPENDIX 1a Items n) to u)
- C. Reviewers requested that other aquatic components, like sediment, benthic macroinvertebrates, and testing for mercury (Hg) be included in the study design. The former two issues have been vetted by the Board and their environmental consultant (HESL) for this AEMP design and therefore the Board must continue to support the study design without these two elements at this time. Imperial agreed to include Hg in fish tissue sampling. The Board agrees that these issues may be revisited, based on review of the AEMP data, if warranted in future years - ISSUES AGREED TO BE ADDRESSED IN FUTURE AEMP DESIGN REVIEWS –see BELOW and APPENDIX 1a Items v) to x).
- D. Reviewers made detailed comments and recommendations on some of the statistical analyses and tests that were applied to the data, as well as an overall assessment of the report quality and acceptability. IORL did not respond to these comments; however, a response was not essential for these since most of the recommendations for improving the statistical tests used for data analysis, revising objectives, sampling design, etc. will be carried forward and incorporated in the updated and revised AEMP version 4.0 submission - ISSUES NOT RESPONDED TO BY IMPERIAL – see APPENDIX 1a Items y) to cc).

The rationale for decisions on the key issues are as follows:

ISSUE C - AEMP Components – Sediment, Benthic Macroinvertebrate and Hg Sampling

GNWT requested that Sediment and Benthic Macroinvertebrate Sampling be considered in future designs to rule out sediment as a contaminant sink (ID 3) and that future AEMP sampling events should assess the potential for Hg biomagnification and incorporate the results into the response plan framework, and initiate a small-bodied fish survey to further assess the potential biomagnification of Hg (mercury) based on the results of Hg in surface water (ID 13).

Evidence GNWT 13

- Metals and especially hydrocarbons partition into sediments and therefore an investigation of analytes of potential concern in sediments should be conducted with the addition of sediment sampling to rule out sediments as a contaminant sink.
- Due to known micro-scale heterogeneity of hydrocarbons in sediments, composite samples should be used to increase spatial coverage (i.e., 3 cores should be taken at a single sampling location and mechanically composited).
- Analytical detection limits should be 50% of those analytes with sediment quality guidelines to ensure the micro-scale dilution does not lead to a false non-detect.
- It is acknowledged that the local receiving environment is very dynamic with massive transport of suspended solids. Sampling locations that are “net depositional” should be prioritized (i.e., not in an erosional zone) over the ideal scenario that sediment sampling locations would be the same as water quality sampling locations.
- The depth of sediment that represents recent inputs should be considered to avoid dilution with sediment deposited prior to development of the IORL site.
- BC Ministry of Water, Land and Air Protection (2002) provides guidance on monitoring sediment deposition in streams and federal environmental effects monitoring programs provide guidance on sediment sampling to support investigations of cause when effects on benthic macroinvertebrates are of concern.
- To date, effects-based studies of sediment-related exposure are limited to benthic macroinvertebrate studies conducted in Bosworth Creek in 2009-2011 and a study conducted in the Mackenzie River in 1980.
- A benthic macroinvertebrate study in the Mackenzie River should be initiated because:
 - 1) it appears that more than 40 years have passed since the last study was conducted;
 - 2) sequestration of contaminants within sediments has not been ruled out; and
 - 3) reviewers have identified the need for an effects-based study (e.g., HESL, 2021).

Evidence Imperial

- Imperial is not planning to conduct sediments sampling as per direction received by SLWB and HESL. However, large, and small body fish tissues will be analyzed for petroleum hydrocarbons.
- Sessile benthic invertebrates could be considered in the future, pending result from fish tissues investigation.
- Regarding SLWB specific recommendation on sediment sampling, “The board supports the following specific recommendations from the HESL 2021 TR: “Sediment sampling is not recommended as a necessary component of the AEMP because the dynamic sedimentation and erosions processes in the river do not create a stable depositional environment for depositional records.”

Therefore

1. SLWB recommends that future reviews of the AEMP data and assessment will be a venue for assessing the need to conduct further sampling on other aquatic components such as, but not limited to, sediment and benthic macroinvertebrates.

The 2021 Annual Report has met the requirements for submission by the Licensee. Imperial has agreed to consider and integrate all recommendations for revisions to improve the quality of AEMP version 4.0.

3.2 Part I: SPECIAL EFFECTS STUDY

The requirements for the SES are outlined in Part I, Condition 1 and Schedule 6, Condition 1 of the current Water Licence, S13L1-007 issued on March 4, 2015. This condition required that Imperial conduct a Special Effects Study (SES) Report to “establish any threat posed by metals and ions in surface or groundwater by monitoring in the Mackenzie River, upstream of the facility and at the groundwater (GW) SNP (surveillance network program) sites listed in Annex A, Part G, for a period of two years (minimum 12 samples), and submit to the Board for approval” (SWLB 2015 Schedule 6 Part 1b).

Six years later, the SWLB reiterated this requirement stating: “There is a real need to complete this SES to determine the importance of monitoring metals and ions in the AEMP, to determine whether there is any hydraulic connection between the groundwater and the river that could potentially result in adverse impacts, to ensure that the AEMP will monitor all relevant COPC, and to determine if “Effluent Quality Criteria (EQC) are required for the groundwater SNP stations based on the results of the monitoring and trend analysis three months following end of sampling (Licence S13L1-007 Schedule 6, Item 2)” (SWLB 2021⁴).

These Reasons for Decision are based on the following issues raised during the regulatory proceeding:

The Plain Language Summary was unclear in describing the visible sheen test as an authorized method for releasing waters to surface water receiving environments. Imperial clarified that runoff water released from Category A locations is released to land and not directly to surface water. SLWB would like further clarification and description of the process for discharging all releases of water from Category A island bunkers. - ISSUES REQUIRING FURTHER CLARIFICATION FROM IMPERIAL – see BELOW and DECISION LETTER.

Imperial provided clarification of a few comments - ISSUES CLARIFIED and RESOLVED – see APPENDIX 1b – Items a) to c).

IORL submitted additional information in response to requests for more fulsome descriptions of the methods for background “reference” well distinction and Imperial agreed to - ISSUES WHERE ADDITIONAL INFORMATION SUBMITTED AND AGREED TO BE UPDATED – see BELOW.

When IORL completed the SES, the only Category A SWROFs with sheen were the island bunkers. IORL agreed that additional sampling for other types would be beneficial and have agreed to complete additional testing in May of 2023 - ISSUES TO BE ADDRESSED IN 2023 SAMPLING EVENTS - see BELOW.

⁴ See Public Registry for S13L1-007 - [Board direction for Imperial AEMP](#) – Sept 23, 2021

There were several comments and recommendations on the trigger analysis with request that the SLWB modify/refine the triggers and IORL redo the trigger analysis based on the modified triggers – see BELOW and APPENDIX 2a for detailed evidence and recommendations.

There were several comments and recommendations pertaining to the linkage of the Special Effects Study with the Groundwater Monitoring SNP Program. Several findings from the SES support the need for updating and revising the GMP and to complete further assessment of hydraulic interconnectivity of the shallow and deeper groundwater to the Mackenzie River- see BELOW.

IORL has agreed to continue to explore the issues that will assist the SLWB to determine the need for Effluent Quality Criteria in future licence renewal - ISSUES TO BE ADDRESSED IN UPDATES TO SPECIAL EFFECTS STUDY (SES) AND GROUNDWATER MONITORING PROGRAM (GMP) – see Appendix 1b) – Items d) to g} and APPENDIX 2b.

One issue that arose and needs to be addressed in the upcoming Licence renewal is that the definition and distinction of Category A and B SWROFs need to be confirmed and evaluated to determine if all SWROFs should be subject to the same analytical testing requirements. ISSUES NOT AGREED TO - ADDRESS IN LICENCE RENEWAL– see BELOW.

The GNWT-ENR-EAM recommended that the Board not approve the Special Effects Study, and to direct IORL to revise the study design based on the recommendations provided and to resubmit the study design for approval - ISSUES NOT AGREED TO - see BELOW.

The rationale for the decisions on the key issues follows:

Issue A - Visible Sheen Method⁵

Evidence

- Additional details are requested on where this method is currently authorized as criteria for releasing waters to surface water receiving environments? (GNWT 29)
- Runoff water released from Category A locations is released to land and not directly to surface water (Imperial response).
- Clarify the process for discharging all releases of water from Category A island bunkers (SLWB).

Issue C – Background Wells Assessment and Methods

Reviewers noted that the methods section of the SES report and Appendix G describing the selection of wells for the GMP SNP Program contain numerous deficiencies and issues, which makes understanding Imperial's methodology more difficult than necessary. One of the most common issues is the use of the word "background" to describe wells that are located within active operations. SRRB 19 requested Imperial to redefine background, or at least stop using the term "background" and start using the term "reference" if comparing active operations sites with less impacted sites.

⁵ ENR notes that for other jurisdictions, such as British Columbia, the visible sheen method is allowed for the evaluation of hydrotest water and surface water runoff prior to discharging to land, but not surface or groundwaters (BC Oil and Gas Regulation User's Guide). In Alberta, there are narrative aquatic life and aesthetic water quality guidelines that state that no visual sheen should be present in waters).

Evidence SRRB 19, GNWT 47

- The term applied to the wells is particularly important when IOR compares concentrations of chemicals near operations with "background" concentrations. If "background" sites are impacted, then the comparison is misleading and pointless⁶.
- The primary issue with the method section is that the report states that "Four distinct representative contaminant source types were evaluated". These include a total of 21 wells:
 - i. produced water (5 wells),
 - ii. hydrocarbon releases (3 wells),
 - iii. imported shale fill (5 wells) and
 - iv. Sumps on Bear Island and the mainland (8 wells)
- There is no rationalization provided for the four source types, or any source types that may have been omitted (for example the Refinery Bank?).
- The rationalization for choosing the set of 5 wells is unclear and has implications on conclusions because the statistics derived from this grouping of wells is used when making conclusions regarding whether a well that is considered as a background well, is indeed, a background well.
- Additionally, a group of wells is selected by IORL to represent one contamination category. It appears that in some cases, a well could fit into more than one category. The choice of wells comprising a group or sample, directly affects the statistics estimated from this sample.
- As the statistics are then used to make inferences, the reasons for including, or, not including a well in a contamination category, should be clear and, persuasive.

Therefore

2. ENR recommends that IORL provide a more fulsome description of how these categories were decided upon, the degree of separation between each type and, outline any other categories that may have been omitted.
3. ENR recommends that IORL should provide a very strong rationalization when assigning a well to a contaminant source.

Imperial Response Evidence

- Imperial noted that given the challenges in obtaining a representative "background" sample (off site) due to permafrost, the use of the term "reference" is a great recommendation to avoid confusion going forward.
- Imperial submitted a memo to the SES (Appendix G), that provides the rationalization for the selection of the various source types.
- Each of these source types are considered facility-related due to historical operations.
- Only wells representative of specific sources were selected for characterization in order to identify proper metals and members associated to each source.

Issue D – Visible Sheen Test

⁶ The definition of "background" has always been an issue with IOR monitoring programs.

- *"High background concentrations obscure impacts from operations"* and this statement indicates that there may be interaction between operations and "background" sites. (Appendix G - Background Assessment)
- *"For a variety of reasons, most of the 40 wells within the background network are located in disturbed areas of the Site and may be cross-gradient or down-gradient from known sources of impacted soils or natural seepages".*
- *"...background locations in moderately disturbed and non-ideal areas of the Site have been selected based on long-term monitoring..."*

The Special Effects Study was based on a study design submitted in 2015. The submission of the study meets the Licence condition requirement, and the basic intent of the study which was to demonstrate the visible sheen method as effective at detecting hydrocarbons in water that exceed criteria for release to the land. However, the Board agrees with reviewers that the visible sheen method has not demonstrated that the absence of a visible sheen means that surface waters are below criteria and may be released. IORL has agreed to conduct more testing of category A and B SWROFs in May of 2023.

Evidence GNWT 32, 38, SRRB 16, ECCC 2, SLWB 1, 2

- The visible sheen method is subjective and qualitative (what is light sheen? ⁷) meaning that no sheen could still contain levels of petroleum hydrocarbons in surface waters above the limit of 5 mg/L (Imperial) or 10 mg/L (Alberta Directive) and that could lead to traces being released to the Mackenzie River.
- Additional sampling must be done with TPH concentrations as low as the effluent quality criteria (i.e., 5 mg/L) to ensure the method is appropriately sensitive to validate assumptions that a sample with no visible sheen has non-detect hydrocarbons above Guidelines⁸.
- there needs to be samples taken from all types of Category A locations, not just island bunkers to fulfill the study requirements. responded

Evidence Imperial

- At the time of SES, other CAT A sites did not show sheen.
- Imperial will conduct more Category B SWROF sampling, testing and lab analysis in combination with Category A SWROF field screening, sampling, and testing, to confirm TPH and Phenols are below applicable Guidelines when there is no sheen visible.
- Imperial will report on these findings in the May 2023 Monthly Water Use Report due at the end of June 2023⁹.
- IORL will continue to measure petroleum hydrocarbons in the receiving environment (Mackenzie River, Bosworth Creek) as part of the AEMP version 4.0 through grab sample and the deployment of Passive Sampling Devices (PSDs).

Issue E – Trigger Analysis¹⁰

The SES Section 4.1 presents a “trigger analysis”, the purpose of which is “to identify locations where further investigation might be required by comparing concentration time series against three triggers proposed by the SLWB as elements of an adaptive management plan. ENR recommended that the SLWB

⁷ The objective is to determine whether a sheen on the surface of the water indicates higher levels of hydrocarbons in the water phase. The sheen is produced as the water becomes saturated and oil film develops on the surface. It's not surprising that IOR use the sheens as an operational guide, although how to define light sheens is unclear.

⁸ in Table D, the lowest concentration of total petroleum hydrocarbons (TPH) for samples with a visible sheen was 21 mg/L. higher than the concentrations listed for Category B discharges in this licence (5 mg/L) the study has noted that a concentration of 21 mg/L is equivalent to visible, it is unclear whether the visual testing method would be sufficiently sensitive to detect the 5 mg/L limit that is in the licence since samples collected with a sheen did not contain concentrations of TPH at that concentration.

⁹ In 2023, Imperial plans during the month of May typically when discharge events begin during freshet to conduct Category B lab analysis in combination with Category A field screening to confirm TPH and Phenols are below applicable guidelines when there is no sheen visible. These results will be reported in the May 2023 Monthly Water Use report as a follow up to address this concern.

¹⁰ The conclusion of the trigger analysis proposed by SLWB was an identified need to continue monitoring for metals in groundwater as part of the Groundwater Monitoring Program (GMP) SNP and to re-evaluate the Key Indicator Parameters (KIPs) accordingly and to further investigate potential sources of metals in the SNP wells.

adopt their proposed changes to the trigger analysis and wording of the criteria, and that elements of the trigger analysis be redone by comparing forms of measured analytes (total or dissolved) as appropriate with the Water Quality Guidelines (WQG) used. Detailed recommendations and rationale for the proposed changes is in APPENDIX 2a.

Evidence GNWT 30, 39

- The trigger analysis compares dissolved metals and dissolved major ions (IORL 2022b Table F) with CCME WQGs.
- As the majority of CCME WQGs pertain to total metals and major ions, the procedure used by IORL can fail to detect WQG exceedances because dissolved concentrations are typically much lower than total concentrations in natural waters.
- IORL's interpretation of the SLWB (2021) triggers is presented in IORL (2022b Table G).
- The first SWLB (2021) trigger is: "If any parameters with background concentrations that are typically below guidelines, begin to exceed guidelines". The IORL interpretation (IORL 2022b Table G) is ambiguous in that the word "sporadic", and the phrase "always/most often" are used to signify that the trigger is not exceeded.
- ENR also notes that the discussion section of the SES (section 4.3) does state: "The comparison focuses on the dissolved metals identified through the trigger analysis because in groundwater, given the expected low total suspended solids content, the assumption was made that the dissolved and total metals concentrations would be similar given the low likelihood of colloidal transport in surficial sediments".
- First, although this assumption could be verified, there is no reason to simply not use measured total concentrations.
- Second, the explanation for use of dissolved metals when comparing against primarily total metal guidelines should appear in a methods section, not a discussion section.
- see APPENDIX 2a for recommendations for changes to triggers (GNWT 40 – 42).

Therefore

4. ENR recommends that elements of the trigger analysis should be redone by IORL by comparing forms of measured analytes (total or dissolved) as appropriate with the WQG used. Measurements of dissolved analytes should not be compared with WQGs based on total measurements.
5. ENR recommends that IORL ensure that a reasonably conservative estimate be used for screening measured concentrations against the site-specific water quality guideline when it is appropriate to do so.

Evidence Imperial

- The protocol for groundwater sampling does not currently include total metals; however, they plan to collect total metals as part of the GW SNP sampling to allow for a comparison between total and dissolved metals concentrations (dissolved metal concentrations are typically lower than total concentrations in natural waters)
- The purpose of the metal component of the SES was to identify if there is a risk posed by metals in GW to the environment and the results confirmed a need for ongoing sampling of metals in groundwater to refine the risk at locations where triggers were reached.

- Recommendations on changes to the trigger analysis will be considered in updating the GMP and future analysis of the data.
- Results and actions will be shared through annual reporting.

Issue F – Hydraulic Interconnectivity and Key Indicator Parameters

The second objective of the SES was to validate and confirm the contaminants of potential concern for the receiving environment, including metals and hydrocarbons. Imperial stated that the results of the SES identified the need to:

- Continue to monitor groundwater SNP wells for metals and
- Further test the hydraulic interconnectivity.
- Update the GMP to better capture the monitoring of metals in groundwater and potential risk to the Mackenzie River.
- Address the recommendations through updates to the GMP and through Annual Report submissions.

Evidence GNWT 48

- SWLB (2021) stated that: “IORL must understand and document the hydraulic connection between groundwater wells and the river to a) determine any influence of groundwater on the accumulated environmental state that is monitored by the AEMP and b) interpret AEMP findings in a Response Framework.”
- Section 4 of the SES points to Appendix H as the response to this SWLB directive.
- Appendix H includes an assessment of the hydraulic connectivity of SNP program wells to local surface water receptors, stating in that “A full assessment of hydraulic connectivity between the shallow groundwater monitored by the SNP wells and local receptors is beyond the scope of this task” and instead, used a conceptual approach.
- Travel times between SNP wells and “nearby receptors” were estimated to assess potential environmental risks.
- There are concerns with this conceptual approach, namely,
 1. that the groundwater travel times do not provide an assessment of contaminant load to the receptor/water body and
 2. no raw/factual data is provided to support the hydrogeologic flow model assumed in the calculations.
 3. Also noted is that the variability in hydraulic conductivity could result in travel times faster or slower than that calculated likely by an order of magnitude.
- IORL’s consultant, Advisian, admits that the SNP data are “sparse” and concludes that “The groundwater connectivity relationship of local groundwater wells to potential facility-related sources of contamination is not necessarily characterized”.
- The assumption made for this study was “that if the wells are representative of local, facility influenced groundwater, then an assessment of groundwater connectivity between an individual well and a nearby receptor can be inferred to be an assessment of groundwater connectivity between an associated facility and the receptor”.
- If this assumption holds, then estimated travel times are conservative.
- The presence/absence of permafrost barriers would decrease / increase travel times.
- IORL does not make conclusions regarding the presence / absence of hydraulic connectivity, instead recommends that “Once the source is understood, refinement of the understanding of

hydraulic connectivity and potential attenuation along the pathway should be undertaken to better understand the risk to the receptor”.

- Section 5 acknowledges that “The analysis of hydraulic interconnectivity is challenged by the presence of permafrost affecting groundwater flow by creating localized hydraulic barriers.

Therefore

6. Imperial suggests that the hydraulic connectivity assessment be “refined” with an implication that refinement be focused on “higher risk locations”. These “higher risk” locations should be identified through an updated trigger analysis and use of conservatively estimated contaminant loadings to the Mackenzie River or Bosworth Creek, that suggest potential for exceedance of a relevant WQG. Refinement should include:
 - i. Further ground-truthing / site monitoring to confirm/refute the connectivity to the receptor/water body for “higher risk locations”.
 - ii. Various options for ground-truthing exist, such as installation of additional monitoring wells between SNP wells and receptor locations or conducting electromagnetic surveys to identify plume extents.

Issue H - Definition and Testing criteria for (SWROFs)

Two issues were identified to be carried forward for further discussion and review during the upcoming Licence renewal:

1. Definition of Surface Water RunOff Facilities (SWROFs) - definition and distinction of Category A and B SWROFs need to be confirmed.
2. Testing criteria for SWROFs - should both types be subject to the same analytical testing requirements?

Evidence

- IORL are following Licence conditions and will continue field testing at Category A locations prior to release, as per Annex A SNP Part E: Condition 1 (IOR response to SLWB 2)
- Category B SWROFs which are subject to full sample and testing requirements, account for 94% of total discharge volumes per year, while Category A SWROFs account for only 6% of this annual volume (IOR response to SLWB 2).
- the SES validates that the visual presence of sheen indicates [high] hydrocarbon concentrations above criteria (IOR response to SRRB 16).
- The data do not support removing the obligation to monitor concentrations of hydrocarbons and metals in water before any release to the Mackenzie, or anywhere off site (SRRB 16).

Issue I - Report Acceptability¹¹

GNWT 28 recommended the SLWB not approve the SES by IORL and require IORL to address the recommendations herein and resubmit a study design to the SLWB for approval.

¹¹ ENR recommendation for not approving is based on the conclusions reached by IORL relying on the results of:

1) a trigger analysis, as supported by a rationalization of choice of background locations, and,
2) hydraulic connectivity of on-site wells with the Mackenzie River and Bosworth Creek.

Because of the substantive recommendations regarding these three topics (presented below), the defensibility of conclusions reached at this time regarding the requirements for EQCs is not clear. The SLWB should review conclusions regarding the requirements for EQCs only after the recommendations made herein have been addressed.

Evidence (IOR response to GNWT 28)

- Imperial is of the opinion that the SES met the intent of the study in establishing any threat posed by metals in surface or groundwater to the environment.
- The SES identified the need to continue monitoring for metals in the groundwater SNP network to further refine the risk at the SNP location. As a result, Groundwater SNP locations requiring additional investigation were flagged.
- Imperial is in the process to update the Groundwater Monitoring Plan (GMP) to capture monitoring and analysis of metals in groundwater.
- Data Analysis and Reporting results specific to metals in the GW SNP network will be reported through Annual Reports required by the Licence.

4.0 Conclusion

Imperial has met the Licence requirements for submission of the 2021 AEMP Annual Report and the Special Effects Study. The results of the studies have demonstrated a need to revise and refine the AEMP design as well as to carry out additional sampling for the SES and to update and revise the Groundwater Monitoring Plan and SNP program. Recommendations from reviewers have contributed meaningfully to improve the program designs and Imperial has accepted most of these recommendations.

In response to the review of the Special Effects Study, Imperial identified the following actionable items:

1. Continue monitoring for total and dissolved metals in groundwater as part of the Groundwater Monitoring Program (GWMP) SNP.
2. Re-evaluate the Key Indicator Parameters (KIPs) for metals and update data analysis.
3. Further investigate potential sources of metals in the SNP GW wells.
4. Update GMP CCME WQGs – total metals and major ions.
5. Work with SLWB to revise Triggers per GNWT recommendations.
6. Imperial will start using “reference site” instead background when data suggest no known impacts from known sources.
7. Update to the GMP¹².
8. The need for EQC will be refined as part of the GMP and analysis of the data. SLWB propose to carry forward consideration of EQCs in the Licence Renewal.
9. Amend the requirements for metals testing in WL to include total metals based on GNWT evidence ID 30.
10. Future reviews of the AEMP data and assessment will be the means to reassess the need to conduct further sampling on other aquatic components such as, but not limited to, sediment and benthic macroinvertebrates.

Based on all evidence submitted for this review, it is the decision of the Board:

¹² Part of the further analysis Imperial will be looking into is incorporating the use of existing permafrost data from the current thermistors installed within Norman Wells to assess if permafrost conditions have changed over recent years. Imperial will also be looking into utilizing a broader network of GW monitoring wells that E&PS has installed across the site to assist with progressive reclamation. Select monitoring wells surrounding an SNP well in focus will be selected with hydraulic conductivity measured at all the wells to understand the range in that area to assist with further analysis.

1. To APPROVE 2021 Aquatic effects Monitoring Program Annual Report, noting that
 - i) The implementation of agreed upon recommendations from the review of the 2021 AEMP Annual Report into the AEMP Design, will be reviewed for CONFORMITY during the regulatory review process for AEMP version 4.0.
2. To NOT APPROVE the Special Effects Study as a final report, and DIRECT Imperial to:
 - i) Provide written clarification of the process(es) for discharging all releases of water from Category A island bunkers within 30 days of this letter,
 - ii) Implement the recommendations of reviewers to demonstrate that the visible sheen method is appropriately sensitive to validate the assumption that a sample with no visible sheen has non-detect hydrocarbons above Guidelines, and
 - iii) Resubmit the results of the visible sheen test following May 2023 and any other months of additional testing necessary to sample several types of category A and B SWROFs for results, within 90 days of completion.
 - iv) Carry forward all other recommendations from reviewers identified as actionable items by Imperial, to the proposed update and revision of the Groundwater Monitoring Plan (GMP) and GMP SNP Program, including the trigger analysis, the hydraulic interconnectivity assessment, and the assessment of Key Indicator Parameters, and resubmit to the Board for approval in one year.



Tanya MacIntosh, Chair
Sahtú Land and Water Board

March 28, 2023

Date

APPENDIX 1a

2021 AEMP Annual Report

ISSUES AGREED TO - TO BE ADDRESSED IN AEMP Version 4.0

For many of the Comments and Recommendations, Imperial agreed, noting that they are currently developing and implementing updates to improve Version 4 of the AEMP per feedback/recommendations received from the SLWB and HESL and these recommendations would also be considered in the final design:

- a) Sampling Design and Locations - SLWB 9 Metal Concentrations, SLWB 10 Water Quality differences, SLWB 11 Flow Corrected Trend Analysis, SRRB 8 Locations • sampling and collection will be based on observable events (freshet, high and low flows) for the Mackenzie River. • Stronger sample design is being developed with upstream and downstream control sites near Tulit'a and Fort Good Hope, • Norman Wells sites reduced in # to nearshore and offshore near seeps and operations areas.
- b) Reporting – SLWB 12 Submission of first under-ice sampling results - As per Licence, all samples and data collected in a given calendar year will be reported and included in the subsequent year's Annual Report required by March 31 of each year.
- c) Scope¹³ - GNWT 4 is concerned with the limited scope of the AEMP (i.e., only water quality) and believes that effects-based measurement endpoints should be included as recommended by other reviewers (Munkittrick (2019), HESL (2021) and SWLB (2021)) and that the design of a high quality AEMP is discussed in the INAC (2009) Guidelines¹⁴.

IORL will expand the scope of work to focus on effects-based measurement endpoints, including • both small and large fish monitoring, • an increased water quality program utilizing passive sampling devices (PSDs) targeting PHCs and PAHs. Multiple PSD technologies were tested on the Mackenzie River in 2022 to determine the most effective technology.

- d) Figure Presentation¹⁵ - GNWT 7 – Imperial will work to make figures clearer in future AEMP reports, as described in the comment, to ensure reviewers are able to assess the results of the AEMP more easily and adequately.
- e) Guidelines – GNWT 9 - IORL will review all guidelines used as bases for comparison to ensure that the most up-to-date and relevant guidelines are being applied to the program.
- f) Mercury – GNWT 13 - A small-bodied fish survey be initiated to further assess the potential biomagnification of Hg (mercury) based on the results of Hg in surface water.

¹³ the AEMP is driven by the statement in the design (October 2019): "Previous studies documented no effects on fish or benthic invertebrates from the Imperial site. Until the water quality program shows that Imperial's operations are causing an effect outside the natural variability, no specific fish or benthic invertebrate studies are proposed as part of the AEMP".

ENR notes this statement does not consider that changes in measures of location that remain within the range of appropriate natural variability can cause adverse effects; and a one-at-a-time comparison of analytes does not consider potential synergistic effects of multiple contaminant exposures. Further, this statement also presumes that:

- 1) the current AEMP is sufficiently powerful, as defined within INAC (2009), to reliably detect changes that are of concern, and.
- 2) that all sources of contaminant losses are accounted for by the currently selected water quality sampling locations.

Finally, the statement relies on the adequacy of the previous studies in detecting changes of interest.

¹⁴ Indigenous and Northern Affairs Canada – [Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories](#) (2009).

¹⁵ The graphics provided make it difficult to assess a key question: Is there a chemical gradient? Graphics should be provided that for a single year, plots an analyte concentration against the ordered locations. A smoothing line could be fit to the points comprising a single sampling event, for example, June 2021. Such a graphic would allow reviewers to identify elevated concentrations quickly and easily by position, and, to assess changes if any, by sampling event. Unless necessary, logarithmic transformation of concentration should be avoided as only large changes are visually obvious when doing so.

Further, ENR notes that figures in Appendix D could be improved by not using logarithmic scales on location-specific panels to enable readers to see modest changes in concentrations over time. The symbols used in the trend graphics for an analyte could also be improved by using distinctive symbols in conjunction with colour to better identify individual locations.

- g) Water Quality Correlation with Seasonal Patterns of Discharge – GNWT 17 - The AEMP AR states: “It is known that water quality is highly correlated with seasonal patterns of discharge in the river”. Given that flow-adjustment is a central theme in the data analyses, IORL should support this argument with citations relevant to the local receiving environment, or at least, the Mackenzie River in general.
- h) Correlated Variables – GNWT 19 provided recommendations on logic, utility, and implication which IORL agreed to consider.
- i) Method Improvement¹⁶ - GNWT 27, SRRB 12 Rationale and Methods - IORL will consider the recommended improvements to the methods and analyses. Applicable water quality criteria selection rationale will be included.
- j) Principle Component Analysis (PCA)¹⁷ - SRRB 2 – Statistical analysis to be reviewed and clear objectives outlined along with an explanation regarding how data outliers are treated. IORL confirmed (response to SRRB 5, 9) that outliers were included in statistical analyses. Non-parametric tests were used to minimize the influence of outliers. Ordinary least squares regression also included assumption checks.
- k) Multivariate analysis – SRRB 5, 9 - Re-analyze data using suitable methods to include all potential contaminants. Data transformations and methods used (correlation matrix, orthogonal methods, log ratios if used) by the statistical program need to be included. Suitable statistical approaches to using non-detects should be used. IORL will clarify the methods for dealing with left-censored data to make this clear going forward.
- l) Objectives – SRRB 7 - Collecting samples and analyzing them does not provide a rationale for the report. IORL to establish revised objectives and the specific methods to test them.
- m) Terminology – SRRB 2, SRRB 3 - Wording in future AEMP reports will replace “legacy” contaminants with “historic” contaminants when referring to hydrocarbons.

ISSUES AGREED TO AND ADDITIONAL INFORMATION SUBMITTED

For many of the Comments and Recommendations, Imperial provided additional information, as requested and/or to further respond to the comments.

- n) Winter Under-ice Sampling - SLWB 12 - Imperial provided the requested Addendum that includes a) sampling design/methods, b) number of samples collected, c) sample locations on a map, and d) the results of the 2022 March under-ice sampling with results from June 2021 to October 2021.
- o) Low flow sampling – SRRB 2 - was completed in April of 2022 in parallel of the development of Version 4. Results are shared in this response and will be included in the 2022 Annual Report due March 31, 2023 and subsequent annual reports.

¹⁶ The statistical methods used were correctly selected and, with the exceptions noted, well executed. The analyses could and should be augmented with:

- 1) formal tests for spatial gradients using carefully rationalized analytes unmodified by flow. Synthetic variables, (i.e., a principal component regression) could also be used to augment the spatial analyses of analytes unmodified by flow;
- 2) estimates of achieved power so that the absence of detected trends is not due to a combination of short data vectors and large relative variability; and,
- 3) an analysis of covariance with location as a covariate, time as a continuous independent variable and carefully rationalized analytes, analytes unmodified by flow, as a dependent variable.

¹⁷ PCA is a qualitative method of analysing for patterns in complex data but is not quantitative enough to draw conclusions about the possible impact of the site (see the Hutchinson, HESL, report, Appendix C). But given the use of PCA, more details on data treatment are required. These questions significantly impact the PCA plots and correlation matrices that are presented in the report. Transformations of data, the replacement of values below detection, whether data were normalised or autoscaled prior to analysis need to be described. It appears that the data were analysed using a correlation matrix, although variability is reduced if a covariance matrix is used (which may make interpretation easier). Given the number of sites and potential chemical markers possible, it should be a simple exercise of parametric statistics to test for differences between sites. As it stands, the variability between sites and sample dates, and uncertainty, is too high to draw any conclusions. There should be an explanation about how data outliers are treated as well.

- p) Methods - GNWT 8, SRRB 2 PCA Methodology Documentation, GNWT 10 Temporal Trend Analyses Methods, GNWT 18 LOESS Method, GNWT 20 Censored Variables – IORL submitted 2021 AEMP Statistical Analysis Summary for additional details and further information on the methods for statistical analyses and the PCA's that were completed for the 2021 Annual Report, as requested.
- q) Data – GNWT 16 – IORL provided the raw data for the 2021 AEMP monitoring results in Microsoft Excel to be posted on the public registry.
- r) Loess Method¹⁸ – GNWT 18 – IORL submitted a spreadsheet which reports the residuals of the LOESS Method.
- s) Figures – GNWT 24 – IORL submitted an updated Figure 3-6 .
- t) Table 3-4 – GNWT 25 – 1) ensure that statements are correct, and 2) provide the results of all statistical analyses performed in an Appendix. IORL submitted.
- u) Regression Model Statistics – GNWT 26 – IORL submitted the raw data file containing regression trend analysis results and stats completed for the 2021 Annual report to measure the regression model performance.

ISSUES AGREED TO BE ADDRESSED IN FUTURE AEMP DESIGN REVIEWS

Many of the comments and recommendations are useful and have been previously discussed but should remain available to revisit pending further AEMP results.

- v) Analytes of Concern – GNWT 5 recommend IORL prepare a conceptual site plan to support the selection of analytes of potential concern¹⁹. GNWT 21, SRRB 3 Analytes Considered in Data Analyses²⁰ - Need improved chemical methods for testing hydrocarbons in water, SRRB 18 - IOR needs to rationalize the groups of hydrocarbons being tested and correlate the compounds with the study objectives (e.g. some sites are analyzed for F1 to F4 (up to C36) while others, especially with high TPH, are only analyzed to F1 (BTEX), the most volatile group).
 - Imperial is planning to include Passive Sampling Devices (PSD's) in AEMP Version 4 to improve sampling methods for hydrocarbons in the Mackenzie River with plans to include PAH analysis.
- w) Statistical Analyses - GNWT 22 recommend once analytes of potential concern are appropriately identified, future AEMP data analyses should assess individual analytes using alternative statistical methods.
- x) Summary – ECCC 1 recommended IORL provide further discussion on the potential causes for changes in water chemistry presented in Section 4.0 of the report and any potential future investigations to refine the list of potential causes.

¹⁸ ENR recommends IORL 1) provide the inputs (e.g. degree of smoothing) and settings used for the loess function; and, 2) assess the effect of the degree of polynomial used, and the degree of smoothing from the default values used. The assessment could objectively use as an estimate of congruence, the variance of differences in smoothed values scaled by the variance of the smoothed values using the default loess inputs.

¹⁹ The selection of analytes of potential concern would be better supported through the discussion of past and present site activities, including potential concentrations and/or loads to the receiving environment, proximity to known biological thresholds such as water and sediment quality guidelines, and, degree of increase (concentrations and/or loadings) relative to reference locations and the corresponding link to analytes identified of concern. This should be completed through a conceptual site plan and updates to the current AEMP design.

²⁰ Table 4 lists 6 "indicator" variables (chloride, sulphate, iron, manganese, total dissolved solids (TDS) and total suspended solids (TSS)). It is not clear why these variables were listed as indicator variables (as noted in other comments herein). However, as "indicator" variables indicate some level of importance, it is of concern that neither iron nor manganese was included in the ordinations whenever possible. It is also of concern that hydrocarbons are never included in any ordination. IORL should ensure that whenever possible (i.e., on a dataset-specific basis) variables of interest are included in data analyses. IORL confirmed that hydrocarbons in water samples have never been detected since 2017.

ISSUES NOT RESPONDED TO BY IMPERIAL

Many of these comments and recommendations relate to specific analyses that have been performed on the data and future statistical tests and analyses will consider these comments where relevant.

- y) Principal Component Analysis (PCA)²¹ - GNWT 6 The proportions of explained variability based on the within-location PCA analyses presented in the previous AEMP AR vary considerably from those presented in the 2021 AEMP AR. This suggests that the inclusion of another year of data makes explained variability change considerably. It may highlight the inutility of these analyses.
- z) Temporal Trend Analyses - GNWT 11 IORL to conduct flow-corrected temporal trend analyses for water quality parameters at AEMP-13. IORL to ensure that flow measurement data are available if flow-corrected temporal trend analyses are to form a component of future AEMP data interpretations. IORL to confirm that water level data are available at the Mackenzie River hydrometric station 10KA001 for the time period used to generate the hydraulic equation used to predict flow.
- aa) Flow-adjusted Trend Analyses - GNWT 12 Demonstrate the utility of flow-adjusted temporal trend analyses by including a comparison of trend analyses with and without flow adjustment to demonstrate empirically, that conclusions change when flow-adjusted data are used in temporal trend analyses. Reference data can be used to contextualize observed changes at exposure locations without requiring flow-correction.
- bb) Relative Percent Differences (RPDs) – GNWT 15 Present the colour coding relating to the RPDs in the AEMP AR. Include a data quality assurance section in the AEMP including a graphic showing how the frequency of RPDs > 20%, 50% and 100% by analyte class, have changed over time and, a discussion regarding the results and whether an investigation of quality assurance procedures is warranted.
- cc) Report Acceptability²² SRRB 1 - There are five technical issues that significantly weaken the case presented by Imperial that there are no impacts on the Mackenzie River from operations.
 - 1. Objectives & Criteria
 - 2. Site selection
 - 3. Incomplete Testing of COPC
 - 4. Rationale for minimum # analytes tested.
 - 5. PCA doesn't allow for quantitative evaluation of yes or no impacts.

²¹ The utility of the results conducted on a limited set of analytes is not clear, as it is not known how the variables selected reflect analytes of potential concern and conclusions reached may not necessarily be the same as those reached using a more comprehensive and focused set of water quality variables.

²² The issues include:

1. There are no objectives stated or criteria defined as to how possible impacts from operations will be determined. This still isn't clear after going through the report. Based on the extensive monitoring at the site for decades, IOR should be able to predict "a priori" what compounds and sites should be affected with specific indicator compounds and proper statistical tests and sampling design.
2. The selection of sites tested, including several on shore and only one control site upstream is a problem. No rationale is provided why this design was used. If IOR is trying to establish whether operations are changing water chemistry in the Mackenzie River, then the reasons that sites from onshore at Bear Island and Bosworth creek were included need to be clearly stated. This unbalanced design and the inclusion of several onshore sites makes comparisons between potentially impacted sites in the river and the upstream site difficult. A better design would be several upstream sites and an equal number of nearshore sites at the lease area. Simple statistical comparison of control/impacted for key compounds would be straight forward.
3. IOR has chosen to analyse BTEX and smaller alkanes (<C16) (and no PAHs) to test for the operation's potential impacts. BTEX is usually an indicator of petroleum products and include water soluble but volatile components. A series of papers on hydrocarbons in the Mackenzie River (e.g., Yunker et al.) report alkanes up to C36. The Special Effects Study on sheen reports values for total petroleum hydrocarbons. The BTEX, F1 and F2 fractions (and inorganics) give an incomplete test of compounds that could change water chemistry and indicate impacts.
4. The IOR Annual Water Licence Report (2019) has data for PAHs and F1 to F4 fractions in surface and groundwater. Metals exceeding CCME guidelines in surface groundwater have been reported at Mainland sites. No rationale is provided as to why the minimum analytes were tested or why the earlier data have not been used to design this program.
5. As indicated in Appendix C of the Hutchinson report, the use of principal component analysis is odd because it is not a quantitative method which will allow firm conclusions of yes or no for tests of changes in water chemistry near operations. Appendix A in the Special Studies report clearly shows impacts from BTEX and metals from operations at "background" sites. The question remains whether those impacts extend to the Mackenzie. PCA doesn't allow for quantitative evaluation of those impacts.

Appendix 1b Special Effects Study

ISSUES CLARIFIED - RESOLVED

- a) Sampling Locations - SLWB 4 Recommended samples from Settling Pond and SNP Discharge location to the Mackenzie River analyzed for PHCs. IORL responded that SNP S13L1-007-2 is tested weekly for phenols and TPH as per Annex A Part C Condition 3 and that there are additional safeguards installed within the Cooling Water Loop of the CPF to auto detect hydrocarbons.
- b) Laboratory Results GNWT 35 - Provide a brief description of the difference between F1 BTEX and the individual BTEX compounds? IORL Responded: BTEX refers to the individual compounds of Benzene, Toluene, Ethylbenzene and Xylene which are each volatile organic compounds (VOC) and they are analyzed individually in the lab. F1 BTEX includes an additional analysis for petroleum hydrocarbons specifically in the fraction range C6-C10.
- c) Trigger Analysis Metals SLWB 6 – IORL clarified that all metals will continue to be sampled (total, dissolved) with a subset used for trend analysis.

ISSUES TO BE ADDRESSED IN UPDATES TO SPECIAL EFFECTS STUDY (SES) AND GROUNDWATER MONITORING PROGRAM (GMP)

- d) FWAL Guideline - GNWT 43 commented that screening out metals that have no water quality guideline is unnecessary when the purpose of the investigation is to identify contamination of groundwater from a known source; they need to retain all water quality analytes that are not “heavily” censored when grouping and/or assessing wells using multivariate methods; they need to use the most recent CCME or, other relevant WQGs as necessary. There should be a consistent use of WQGs among supporting documents.
IORL agreed • to consider these recommendations for integration in the GMP update • to conduct a review of the guidelines in use to ensure the most applicable recent guideline are used to compare results.
- e) Site-specific Toxicity Modifying Factors²³ - GNWT 44 ENR recommended that IORL discuss, in the methods section, how site-specific toxicity modifying factors are used and ensure that conservative concentrations are chosen. IORL agreed to adjust the Guideline specific toxicity modifying factors accordingly in future annual GMP SNP reports.
- f) Effluent Quality Criteria – EQC - GNWT 49 ENR recommended and IORL agreed, that the SWLB provide guidance to IORL on appropriate groundwater quality criterion for a non-point source loss. IORL noted that once and if the source of the metals is confirmed as waste, the area would be managed in a similar way as any other site with historical contamination. Groundwater quality criterion / EQC for a non-point source loss will be refined as part of the GMP and analysis of the data and established as needed (see APPENDIX 2c).

²³ Because low pH and hardness exacerbates toxicity of metals the 5th percentile of background water quality estimates of these variables should be used instead of the 95th percentile as was done in the 2014 Annual Closure and Reclamation Progress Report (2015 Appendix E). Note that IORL (2022b Figure F-8a) does use the CCREM (1987) Al guideline of 5 µg/L when pH is < 6.5, as opposed to the higher guideline when pH is ≥ 6.5. Please note that not all figures that present CCME guidelines that can be made site-specific through use of toxicity modifying factors were assessed.

APPENDIX 2a

Trigger Analysis

The SES Section 4.1 presents a “trigger analysis”, the purpose of which is “to identify locations where further investigation might be required by comparing concentration time series against three triggers proposed by the SLWB as elements of an adaptive management plan, and included in their September 24th, 2021, letter (SLWB 2021):

- i) *> CCME FWAL (freshwater aquatic life) (FWAL if naturally < CCME FWAL (if any parameters with background concentrations that are typically below guidelines, begin to exceed guidelines);*
- ii) *> CCME FWAL and > Background if naturally > background (if any parameters with background concentrations that typically exceed guidelines, begin to exceed the naturally elevated background levels); and*
- iii) *Any emergence of an upward trend in 3 consecutive samples (if parameters show an upward trend in concentration from “background”, and this trend is observed over 3 sample intervals).*

SLWB Triggers – proposed revisions

Trigger 1 Evidence - GNWT 39

- The first trigger recommended by SWLB (2021) is: *“If any parameters with background concentrations that are typically below guidelines, begin to exceed guidelines”*. This trigger is itself ambiguous because of the use of the word “typically”, the phrase “begin to exceed” and, because the magnitude of exceedance is not defined. ENR proposes that an unambiguous wording that captures the intent of this trigger is:

The proportion of samples exceeding the relevant WQG at a well must not be more than 10% higher than the proportion of samples exceeding the relevant WQG for a pool of background wells for any running 3-year period.

- The value of 10% was chosen based on detecting a significant change in proportions given the small sample size for exposure locations in any 3-year period.
- WQGs should be selected based on best and most recent science. This may include Canadian Federal Environmental Quality Guidelines, British Columbia WQGs, etc.
- ENR notes that this criterion is self-indexing with respect to temporal trends in background locations and does not require subjective inclusion or exclusion of data.
- A second criterion is required to deal with increased concentrations. ENR proposes that the following wording captures the magnitude of increase:

A median analyte concentration must not exceed the median background analyte concentration by more than 20% for a pool of background wells for any running 3-year period.

- A detailed rationalization for the composition of the pool of applicable background wells must be provided as part of the criterion review.

Therefore

7. ENR recommends that the SLWB adopt this two-part criterion as the first trigger. The clauses should be linked by the logical operator “OR”, as triggering either clause reflects an adverse change.

Trigger 2 Evidence GNWT 41

- The second SWLB (2021) criterion is triggered *“If any parameters with background concentrations that typically exceed guidelines, begin to exceed the naturally elevated background levels”*.
- To exceed this trigger, IORL is suggesting that an analyte concentration in an exposure well must always exceed the CCME WQG, and the analyte concentration changes from less than background concentrations to greater than background concentrations.
- The IORL interpretation does not account for the magnitude of increase, nor does it account for an increase in frequency of exceedances that is between the frequency of exceedances at background locations, and 100%. This trigger is ambiguous for the same reasons presented for the first trigger.

Therefore

8. ENR recommends that the SWLB omit the second trigger.

Trigger 3 Evidence GNWT 42

- The third trigger recommended by SWLB (2021) is: *“If parameters show an upward trend in concentration from “background,” and this trend is observed over three sample intervals”*.
- The method for determining an upward trend is not defined and it is not clear whether the requirement is that the trend be consistent over three sample intervals.
- Water quality concentrations will vary over time.
- Concentrations measured at a specific time will exhibit variation around a trend line.
- Large degrees of variability (i.e., greater than the product of the slope and time interval between successive measurements) will necessarily lead to a situation where successive concentrations are not always greater than the preceding concentration, despite an increasing trend.
- Consequently, the requirement for consistently increasing concentrations should not be required.
- Again, note that it is not clear whether this criterion is required or not.
- ENR proposes an alternative wording that captures the intent of the trigger and is clear as:

A significantly increasing temporal trend as estimated using the Mann-Kendall trend test.

- This test was recommended in consideration of the type of data being generated by the well monitoring program, ease of use and generally accepted usage (See for example references in Gilbert (1987) and US EPA (2009)).
- If data are collected in other seasons, a seasonal variant of this test should be used.
- If trends are also noted in background locations that are not due to Site activities, alternative methods that distinguish between the slopes of trends in exposure and background wells should be used to answer the question: “Are concentrations in exposure wells increasing faster than in background wells?”.

Therefore

9. ENR recommends that SLWB adopt this alternative wording for the third trigger. This trigger, like the others should be linked by the logical operator “OR” as triggering any trigger, reflects an adverse change.

Adoption of these any of this recommendation to change the triggers would require that IORL modify their response to the modified trigger(s).

**APPENDIX 2b
Effluent Quality Criteria (EQC)**

Evidence GNWT 49

- SWLB (2021) refers to the establishment of EQC (effluent quality criteria).
- IORL cites two EQC objectives in the SES from MVLWB/GNWT (2017) but does not discuss the second objective which is that “The amount of waste to be deposited to the receiving environment is minimized”.
- IORL (2022b) correctly points out that: “Establishing EQC is a significant undertaking, especially for a potential non-point source. Aside from the issues established therein, a discussion regarding what comprises a mixing zone for a non-point source is necessary by IORL to back-calculate the ground water quality criterion.
- The concept of an effluent quality criterion or more correctly, a groundwater quality criterion (GQC), requires consideration by the SWLB and consultation with Communities and Regulators.
- That consideration should include the size of mixing zone that is appropriate for a non-point source loss.
- Consideration should also be given to the degree of uncertainty in the flow path (contaminants from multiple sources may channel through a degraded permafrost area, especially one with a higher degree of porosity than surrounding ground).
- Consideration should also be given to the fact that unlike discharge from the end of pipe (i.e., “effluent”), ground water flows cannot easily be “turned off”.
- This suggests that GQC should be more conservative than EQC.
- This guidance should be provided to IORL by the SWLB prior to estimation of GQC by IORL.

Therefore

10. ENR recommends that the SWLB provide guidance to IORL on appropriate groundwater quality criterion for a non-point source loss.
11. ENR recommends that IORL consider both MVWLB / GNWT (2017) objectives for setting EQC. IORL should provide a fulsome discussion of how waste deposition can be minimized. It is acknowledged that “waste” or ground water contamination is historic and consequently, the act of deposition has already occurred. However, collection and remediation, as is consistent with MVLWB /GNWT (2017), rather than accepting passive losses to the Mackenzie River and/or Bosworth Creek, should be discussed.